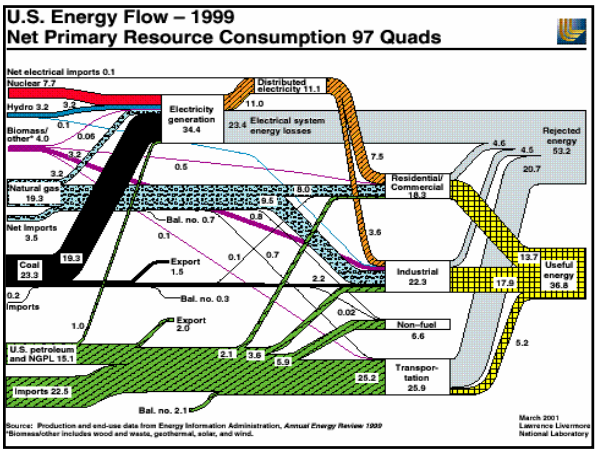
HOUSE AS A SYSTEM
Home Building Solutions Workshop

Building Science Workshop

CHANGE FOR THE BETTER WITH ENERGY STAR

With support from:
Northwest Energy Efficiency Alliance
www.nwalliance.org



"House as a System"

"Building Science"

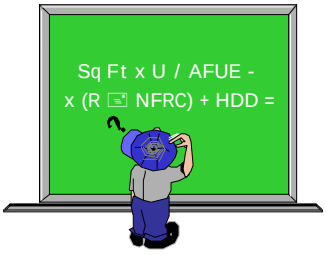
Building

Occupants — Pollutants, Heat loss, Comfort, Operating cost, Moisture, Fire safety — Environment

Mechanical Systems

Energy and Moisture Transport

BS 101

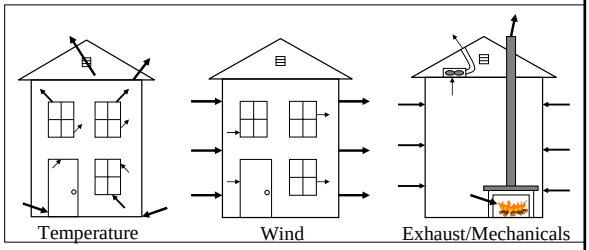


Heat Goes to Cold

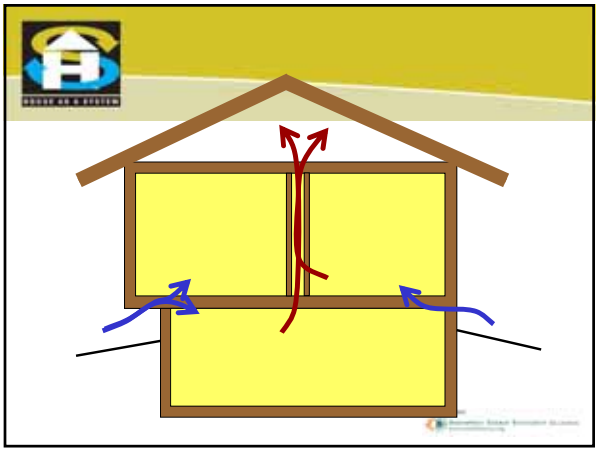
- *Conduction*
- Affected by:
  - Insulation
    - Installation practices
  - Windows
  - Framing techniques

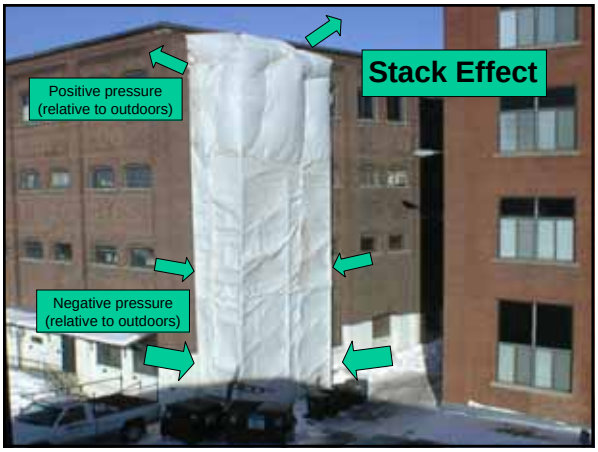
Air Moves Under Pressure

- *Convection*



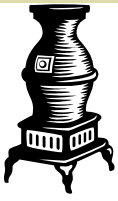
Temperature is typically the dominant effect



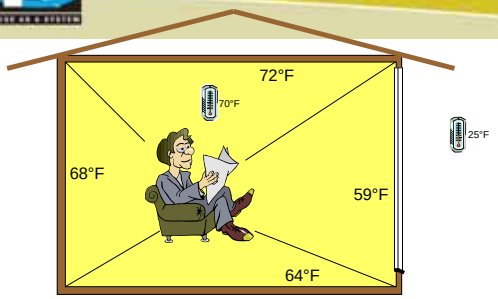


Hot Surfaces Warm You Up

- *Radiation*
  - You feel heat through space, even if the air is cold
  - You feel cold surfaces the same way
- Function of temperature difference, area

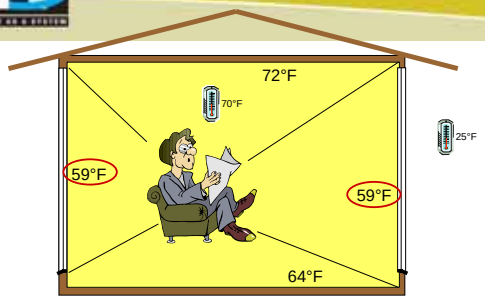


Mean Radiant Temperature



Mean Radiant Temperature: = 67 °F

Surface Area



Mean Radiant Temperature: = 63 °F

Moisture

- Water related to 90% of building and material failures (ASHRAE)
- Estimated $9 Billion/year in repairs

Controlling Mold

- Eliminate mold spores (can't do it!)
- Freeze or burn them (and drive us out too!)
- Control nutrient sources
  - Elimination is difficult
- Control moisture
  - Best strategy

Quotes:

- "Most mold problems are caused by excessive water leakage – what I call stupid stuff. It is simple, obvious stuff, like leaking roofs and missing flashings. And the answer… don't do stupid stuff."
  - Anton TenWolde

They just don't build 'em…

…Like they used to

- Old wood-frame buildings let moisture and energy flow through
- Wall cavities were warmed by heat loss
- Large drying potential in either direction

Why so many moisture problems?

- Reduced drying potential—longer dwell time for water
- More air conditioning
- Less water storage capacity
- Materials that are more sensitive to water
- People doing stupid stuff

Moisture Control Overview

- Control Bulk Water Entry
- Control Water Vapor
  - Diffusion
  - Air Leakage
- Keep Indoor RH between 25-50% (controlling RH is not always easy, shoot low and monitor)
- Keep Condensing Surfaces Warm

What to Control?

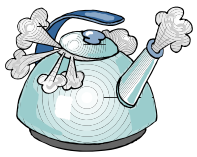
- Source – Can the *source* be controlled
- Path – If the source can't be controlled can the *path* be controlled or managed
- Driving Force – If the path can not be controlled than the *driving force* must be controlled.

Bulk Water

- Mostly from outdoors
  - Gravity
  - Wind
  - Capillary action
- Strategies
  - Roofing / flashing etc.
  - Drainage planes / rain screens
  - Capillary breaks

Water Vapor

- Mostly from indoors
  - Moisture goes to cold
  - Moisture goes to dry
  - Moisture moves on air



How Much Water?

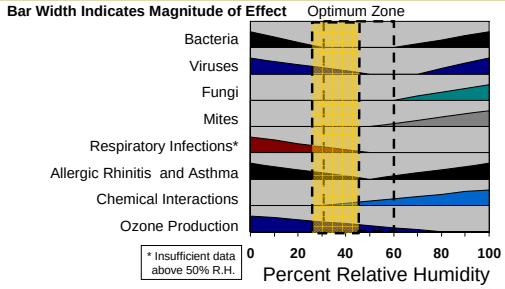
- Daily water vapor produced by family of 4:

– Respiration and perspiration	14 lb
– Showers & bathing	3 lb
– Cooking	2 lb
– Other activities	2 lb
Total	**21 lb = 2.5 gal**

Additional Moisture Sources

- Crawlspace floor: 82 lb/ day = 10 gal/day
- Construction (typ): 2500 lb = 300 gal
- Unvented fireplace: 3.3 lb/hr = 0.4 gal/hr
  - At 40,000 btu/hour input rating
  - Any unvented or improperly operating appliance
- Pool, greenhouse, other large sources

Health Effects of Humidity



Source: ASHRAE Systems and Equipment Handbook, 2000

Controlling Indoor Humidity

- Reduce excess moisture by
  - Source Control (foundation, rainwater)
  - Source exhaust (bath, kitchen)
  - Control background ventilation rate
- Reduce dryness by reducing air exchange
  - Seal up air and duct leakage

Air, Vapor & Weather Barriers

- Weather “barriers”—Housewraps, drainage planes and rain screens
- Vapor diffusion and vapor retarders

Housewrap Qualities

- Provides a drainage layer
  - If properly installed and detailed
- <u>All sheathing papers/wraps</u>:
  - Reduced effectiveness from exposure to raw cedar, redwood, or cement stucco
  - Backprime or use rain screen

Photo Courtesy Dave Ricketts, ©*RDH Building Engineering Ltd.*

Window Details for Drainage

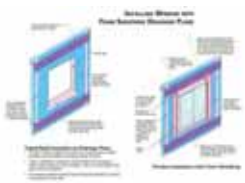
Journal of Light Construction, March 2003

www.buildingscience.com

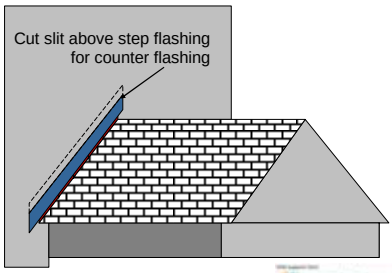
- Click on "Homeowner resources"

www.eeba.org

- Water Management Guide



Roof Flashing Interface



Quotes:

- "Plan your exterior details as if there is a worldwide shortage of caulk. Assume you don't have any."
  - Mark LaLiberte

Vapor Diffusion

- Water vapor moves through *solid* materials
  - Moves towards cold, dry
- "Vapor pressure"
  - Pushes out in the winter
  - Pushes in in the summer

Energy Code

2004 Supplement to IECC: Moisture Control

In all frame walls, floors, and ceilings not ventilated to allow moisture to escape, an approved vapor retarder having a maximum rating of 1.0 perm, … shall be installed on the warm-in-winter side of the thermal insulation

Permeance of Materials

• Housewraps	30-60
• Gypsum board	50
• Paints	0.5-10
• Extruded polystyrene	1 (@1")
• 15-lb felt paper	1.0 - 4.0
• Exterior plywood / OSB	0.8
• Kraft facing on batt	0.4
• Polyethylene (6-mil)	0.06
• Aluminum foil (1-mil)	0.0

Source: ASHRAE Fundamentals 1997

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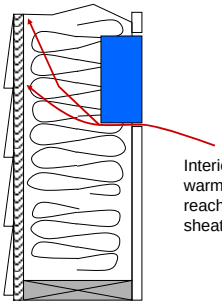
Source: ASHRAE Fundamentals 1997

Air barriers

- What do they have to do with moisture?

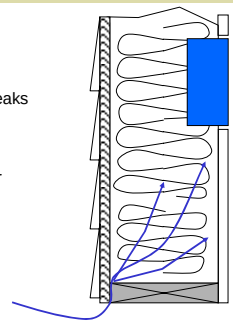
Interior and Exterior Air Barriers



Interior air leaks allow warm humid air to reach the exterior sheathing

Interior and Exterior Air Barriers`

Exterior air leaks allow wind washing and chilling of interior vapor barrier



Preventing Condensation

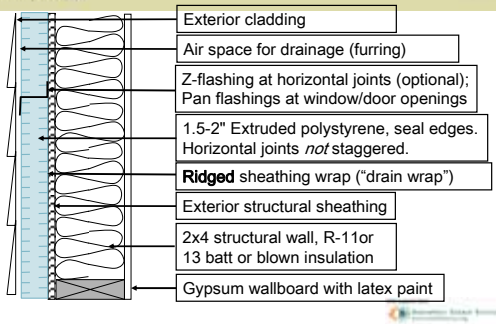
- Humidity control
- Limit air flow
- Keep vapor retarder warm w/ proper insulation
- Exterior rigid foam board
  - Keeps sheathing warm

A Rain Screen Wall

From *Fine Homebuilding*
February/March 2001

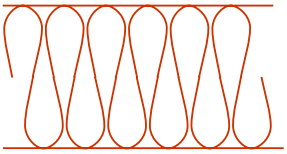
Rain Screen

Moisture-resistant Cold Climate Wall



HOUSE AS A SYSTEM
Home Building Solutions Workshop

Insulation



Insulation Materials

- Fiberglass
- Cellulose
- Foam
- Cotton
- Wool

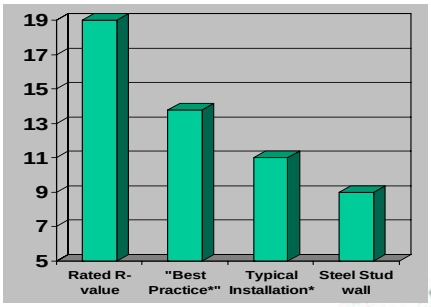
Installation Methods

- Loose fill
- Batts and blankets
- Blow-in-systems: BIBS, Spider
- Open cavity spray

ENERGY STAR® Requirements

- Fiberglass batts must be installed to manufacturers specifications:
  - Fully lofted
  - Completely fill framing cavity
  - No voids or gaps
  - Cut to fit neatly around all obstructions
- Flanges of faced batts must be stapled *over* framing members
- Vapor retarder required as per building code

Fiberglass Batts (Real World)



Why is it So Bad?

- The gaps and spaces dominate the heat loss
  - No matter how much insulation you pile up next to a gap, the heat loss through the gap is not reduced at all
- The larger the initial R-value, the greater the effect

Typical installations…

Typical installations…

Typical installations…

Typical installations…

Typical installations…

Typical installations…

Typical installations…

Correct Installation

Loose Fill Fiberglass Methods

Blow-in-Blanket System (BIBS)

Spider

- Loose fill fiberglass installed behind netting stapled over framing members
- Installed R-value dependent on density
- Typical for a 2x6 wall is R-21 to R-23

Blow-in-Blanket (BIBS) Fiberglass

Spider

Cellulose Insulation Methods

- Blown in open attics
  - Desired R-value achieved by installing the number of bags specified by the manufacturer (by square feet)
- Dense-Pack systems (similar to BIBS)
- Open Cavity Damp Spray
  - Typical for a 2x6 wall is R-21 to R-23

Blown Cellulose Insulation

Damp spray cellulose

Finished Product

Dense-packed Cellulose

Dense Pack Cellulose

Foam Insulation

- Rigid foams:
  - Expanded polystyrene (EPS): R-4 per inch
  - Extruded polystyrene (XPS): R-5 per inch
  - Polyisocyanurate: R-7 per inch

Spray Foam Insulation

Spray Foams:
- R3.5 to R-7 per inch
- Density Matters:
  - 0.5 lb/cu ft = R-3.8 per inch
  - 2.0 lb/cu ft = R-6.8 per inch

Spray Foams

- Excellent air sealing
- Excellent "fit"
- R-value depends on density
- Vapor transmission depends on density

Targeted Spray Foam

- Band joist area
- Rafter / ceiling joist
- Wall intersection
- Difficult areas
  - Dormers
  - Odd framing bays
  - Unvented roofs
- Ducts in attic

Spray Foam

Hybrid Spray Foam

- 2 – 3 inches of foam
  - Air sealing
  - High R-value
  - Tight spots
  - Moisture protection
- Fiberglass
  - cheap

Spray-in Insualtion Weakness

Flash foam and cotton batt

Foundations

ENERGY STAR® Requirements

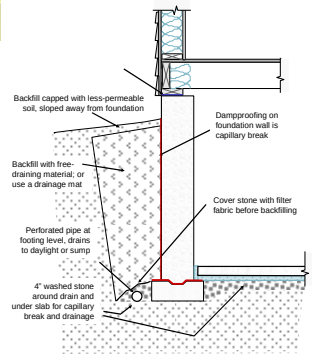
There are no specific requirements for foundation construction in the Northwest ENERGY STAR® Homes program

• Basements used as conditioned space must have R-19 wall insulation

• Slabs in heated space must have R-15 rigid insulation 2' vertical or horizontal along the slab edge

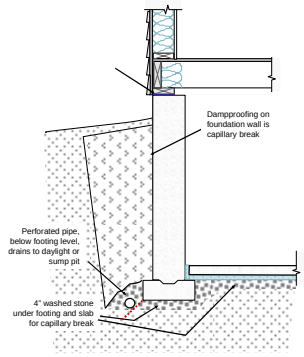
Foundation Water Control

- Control flow of rain and ground water
- Control capillary flow
- Control vapor diffusion



Foundation Water Control

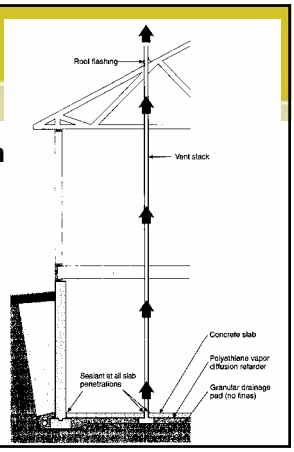
- Better:
- Add drainage/cap break *under footing*
- Important
  - Washed, uniform sized stone
  - Drain pipe outside 45º from footing corner



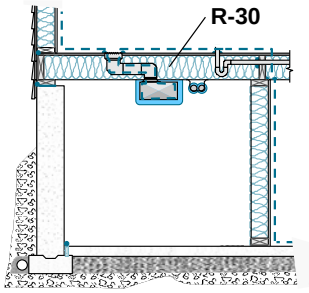
Soil Gas Vent System

- Stack effect or added fan vents soil gases outdoors
- Relieves negative pressure between slab and basement

From EEBA Cold Climate Builder's Guide, Fig 4.5

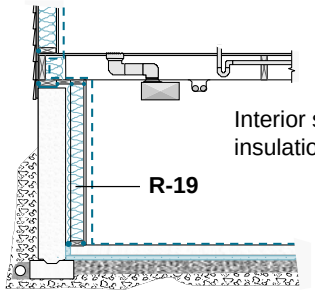


Insulation Options



Insulated floor over unheated basement, crawlspace or garage

Insulation Options

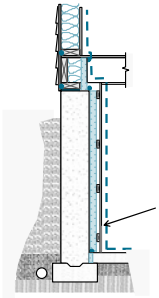


Interior stud wall insulation

DON'T DO THIS!!!

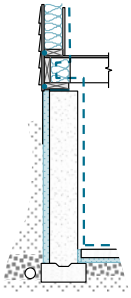
Poly on inside of foundation wall!

Insulation Options



Basement with Interior Rigid Foam

Insulation Options



Basement with Exterior Rigid Foam

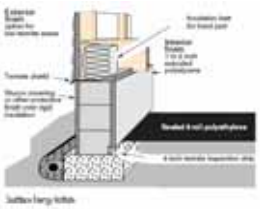
What sometimes happens…

Detailing Vented Crawl Spaces

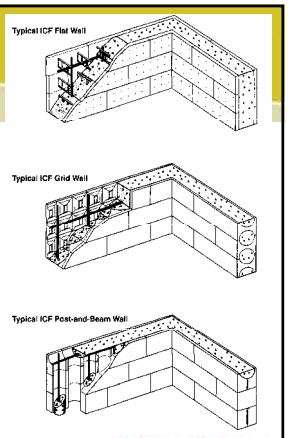
- Impeccable ground cover
  - Sealed at seams and edges
- Insulation touching subfloor
- Seal all penetrations in subfloor
- Use foundation water management tactics
- Install drain or sump

Unvented Crawlspace

- Less insulation
- Ducts and pipes in heated space
- "Rat" slab
- ICF walls



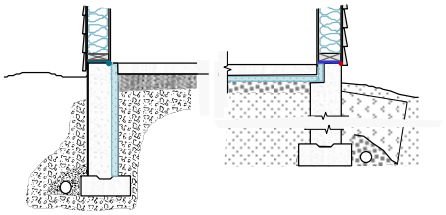
Insulating Concrete Forms



From EEBA Cold Climate Builder's Guide, Fig 6.1

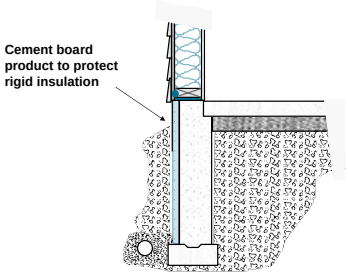
Typical ICF Construction

Slab Edge: Interior Insulation



Slab Insulation

Slab Edge: Exterior Insulation



Exterior Foundation Insulation

Exterior Foundation Insulation

Framing

ENERGY STAR® Requirements

- The Northwest **ENERGY STAR®** homes program allows Advanced Framing options, check with your local Builder Outreach contact for more information…

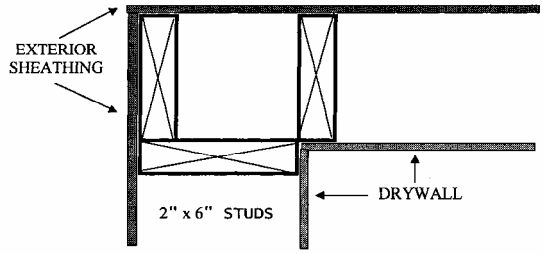
Framing for Energy Efficiency

- Ensures that all framing cavities can be insulated properly
- Allows for increasing insulation in commonly under-insulated areas
- Increase overall R-value by reducing amount of framing material used
- Incorporates air-sealing techniques

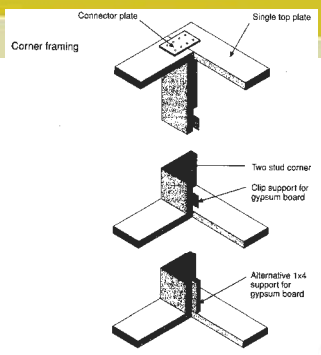
Insulating Steel-Framed Walls

- Steel frame is good heat conductor
  - Narrow section but large surface area
- Tests conducted by AISI / NAHB
  - 6" fiberglass @ 24 o.c. = R 10.1
  - Perfect installation
- ENERGY STAR® analysis:
  - 6" fiberglass @ 16 o.c. = R 7.2
  - Typical installation

Traditional Exterior Corner

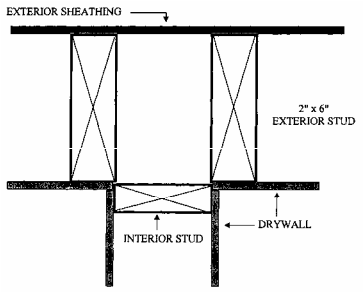


Alternate Exterior Corner



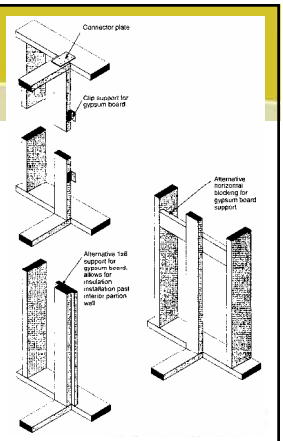
From EEBA Cold Climate Builder's Guide, Fig 5.3

Traditional Interior/Exterior Wall Intersection



Alternate Interior/ Exterior Wall Intersection

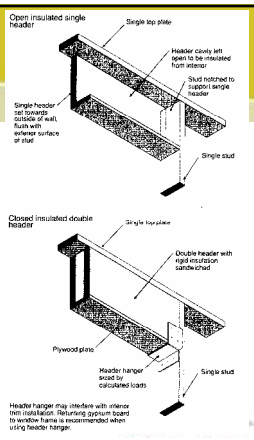
From EEBA Cold Climate Builder's Guide, Fig 5.4



Headers

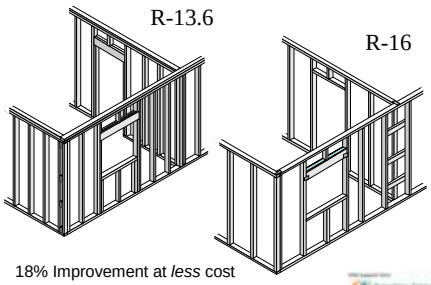
- Eliminate solid wood headers in non load bearing walls
- Insulate headers in bearing walls

From EEBA Cold Climate Builder's Guide, Fig 5.5



Insulated Header

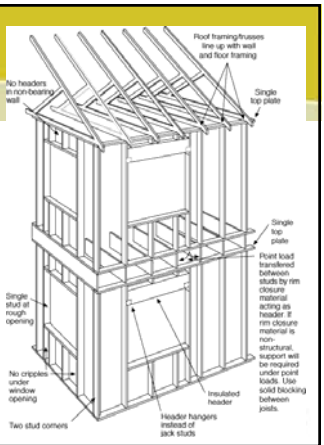
Reducing Framing Material



18% Improvement at *less* cost

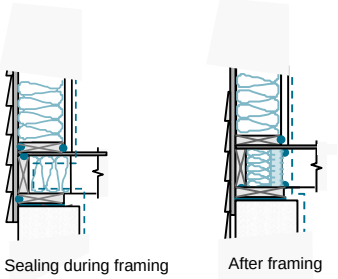
Double 2x12: Holding up 3 cripples and 12 sq ft of plywood…

in a gable end wall



Other Ideas…

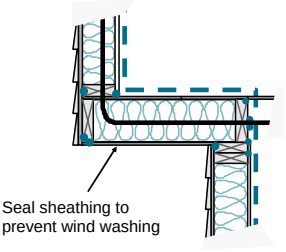
Sealing Leaks – Foundation/sill:



Sealing during framing

After framing

Cantilevered Floor

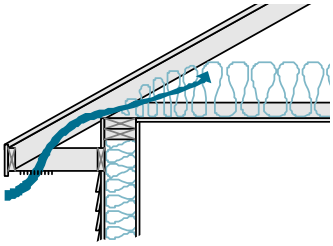


Seal sheathing to prevent wind washing

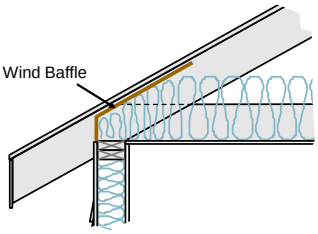
Sealing Framing Leaks

Correct Detail

Truss / Wall Plate Connection



Rafter / Wall Plate Connection



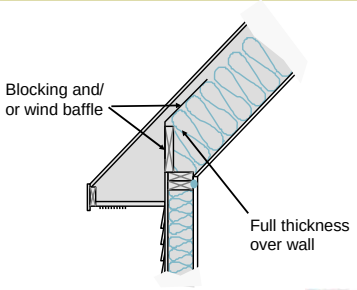
Eave baffles

Pre-cut for 16 o.c. or 24 o.c.
Staple in place fast
Help prevent wind washing
Prevent filling of soffit area
No need for “propa-vents”

Rigid Foam as Baffle / Vent

Spray Foam at Eaves

Cathedral Ceilings



Windows

"Insulating Glass"

- This name is commonly applied to double glazing
  - Approximately R-2
- > 5 times the heat loss as the worst wall anyone is likely to build today (R-11)

ENERGY STAR® Requirements

- BOP 1 Windows must have U-Value of 0.35 or lower
- BOP 2 Windows must have a U-Value of 0.30 or lower
- Sky Lights 0.50 (no more than 5% of conditioned floor area)
- Window and skylight total area can not exceed 21% of conditioned floor area
- 1% of glazing is exempt…Decorative glass

Basic Glazing Types

- Single
- Double
- Low-e
- Gas fills (argon, krypton)
- Heat mirror (extra low-e films)

NFRC Label

Window Surface Temperature

Glass surface temperature at 25°F outdoor, 70°F indoor temperature:

- Single glass 52 °F
- Double glass 59 °F
- Low E + Argon 62 °F
- High performance 64 °F
  (Heat mirror films)

Window Ideas

- Low-E cuts cooling loads
  - Save money on A/C installation
  - "Southern" low-e for large East & West glass
- Use lower U-values for largest units
  - "biggest bang for buck" for ENERGY STAR, and code compliance
  - Improves comfort

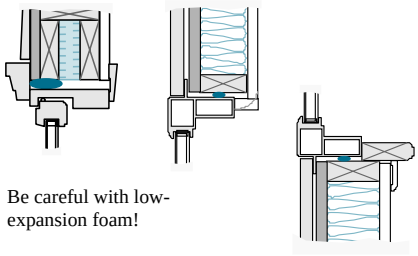
Window Trends

- Warm edge" spacers
- Fiberglass frames


Photo © Kevin Kennefick 2001

Another idea…..

Sealing Around Windows



Be careful with low-expansion foam!

Air Sealing

What is air sealing?

Energy efficiency?

Fire Safety?

Energy Code Corner

402.4 Air leakage (IECC 2004)

- **Building Thermal Envelope.** The building thermal Envelope shall be durably sealed to limit infiltration…The *following* shall be caulked, gasketed, weather-stripped, or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams and penetrations

How many joints, seams and penetration in this building?

The rest of the list…

2. Site-built windows, doors and skylights
3. Openings between window and door assemblies and their respective jambs and framing
4. Utility penetrations
5. Dropped ceilings or chases adjacent to the thermal envelope
6. Knee walls
7. Walls and ceilings separating a garage from a conditioned space
8. Behind tubs and showers on exterior walls
9. Common walls between dwelling units

AND…

The number 10 place to seal up…

10. Other sources of infiltration!

ENERGY STAR **Requirements**

- Northwest ENERGY STAR defers to code requirements for sealing of penetrations in the building envelope and ventilation requirements.
- Some utility programs may require Blower Door testing and/or mechanical ventilation for incentive eligibility.

Blower Door Test

- Depressurizes house
- Measures air leakage
  - Air Changes per Hour (ACH)
  - Code ACH 0.40
  - Energy Star 0.35
- Finds leaks

Air Leaks

- 30% of heat loss in “typical” home
- Transport moisture
- Reduce comfort
- Increase indoor pollution
- Largest cause of ice dams

Air leaks move moisture vapor into walls and attics

Air leaks are largest cause of ice dams

…and pipe freezing problems

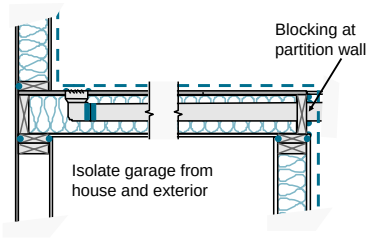
Where Does Air Leak?

At transitions between building surfaces

- Where one material meets another
- Where walls/floors/roof lines meet
- Where empty spaces are hidden by drywall

Insulation DOES NOT stop AIR leaks!!!

Tuck-Under Garage



3606.2.7 Firestopping: Firestopping shall be provided to cut off all concealed draft openings (both vertical and horizontal) and to form an effective fire barrier between stories, and between a top story and the roof space. Firestopping shall be provided in wood-frame construction in the following locations.

1. In concealed spaces of stud walls and partitions, including furred spaces, at the ceiling and floor level;
2. At all interconnections between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings, cove ceilings, etc.;
3. *In concealed spaces between stair stringers at* the top and bottom of the run;
4. At openings around vents, pipes, ducts, chimneys and fireplaces at ceiling and floor level, with noncombustible materials.

780 CMR - Sixth Edition 535
9/19/97 (Effective 2/28/97) - corrected

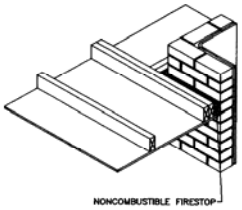


FIGURE 602.7i FIRESTOPPING — AROUND CHIMNEYS AND FIREPLACES

Source: Application and Commentary
CABO One and Two Family Dwelling Code 1995 Editic

Electrical wiring blamed for fire on North Street

"The wood stove pipes were boxed into the interior wall system, which is what we call a 'chase,'" McGowan explained. "The chase drew the fire straight up into the attic. The building suffered heavy damage in the attic and roof assembly and in the second-floor bathroom. There was heavy smoke and

wood stove pipe from the basement to the attic.

"The wood stove pipes were boxed into the interior wall system, which is what we call a 'chase,'" McGowan explained. "The chase drew the fire straight up into the attic. The building suffered heavy damage in the attic and roof assem-

"I want to give the firefighters credit for the tremendous physical exertion they put in to save what was saved there," McGowan said. "Usually in a fire of that type, there wouldn't be anything left standing. I also want to thank the teams from Pownal, Bennington, and Hancock for all their assistance."

Good Job!

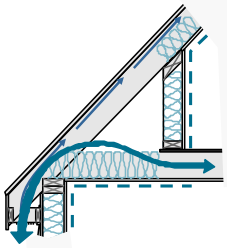
Oops!

Other Big Leaks

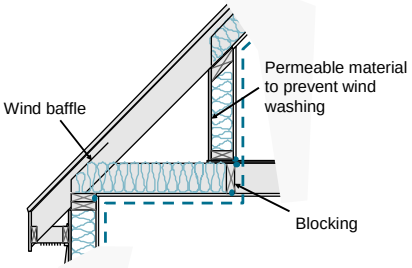
Penetrations

Seal Penetrations

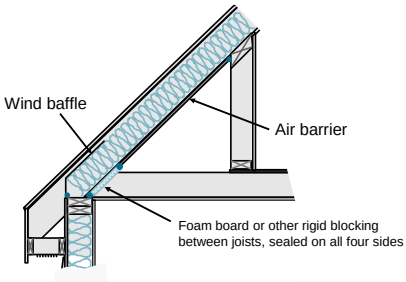
Knee Wall



Knee Wall Solution



Knee Wall Alternate



Advanced Building Systems

Type	Est. ACH nat
Target	.35
Frame - spot sealing	.35 - .25
Frame - spray foam	.20 - .10
SIPS	.25 - .15?
ICF	.15 - .10
AAC	.15 - .10?

Blower Door Test

Pass the test!

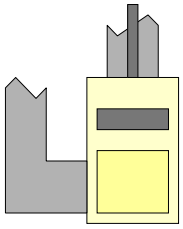
But a House Needs to Breathe!

- People need to breathe
  - Fresh air ventilation
- Random leakage = DRAFTS
- Ventilation replaces drafts
  - Little, if any, energy penalty

Buildings Dry Out

- Vapor diffusion
- Air movement NOT needed
- Air movement can cause more problems than it solves
- Fresh air ventilation

HVAC



Breathing (?)

- Capillary control
- Drying (air movement and diffusion)
- Fresh air

NOT random air leakage in buildings

Improving Indoor Air Quality

- Eliminate pollution sources
- Minimize unavoidable pollution sources
- Separate pollutants from occupants
- Ventilate:
  - Exhaust known pollutants at their source
  - Supply fresh (cleaner) air to dilute remaining pollutants

ENERGY STAR® Requirements

- Mechanical ventilation is not required by the Northwest ENERGY STAR program
- Measured air leakage is also not required
- Local Code should be consulted for regionally specific requirements
- Local Utility programs may require ventilation and air leakage testing

Air Exchange Ventilation

- Indoor air is exhausted from house
- Outdoor air is supplied to house
- Air exchange can occur
  - Naturally
  - Mechanically
  - Or a combination of both

Natural Air Exchange

- Unreliable, due to:
  - Dependency on outdoor conditions (temperature, wind)
  - Lack of occupant control (when, where, and how much)

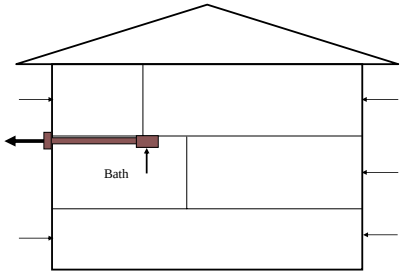
Mechanical Air Exchange

- Reliable
- Occupant control of when, where, and how much
- Outdoor air can be treated as it enters the house (heat, cool, filter)
- Allows houses to be built tighter by providing fresh air and controlling moisture in winter

Air Exchange Strategies

- Exhaust fan only
- Supply fan only
- Exhaust and supply fans

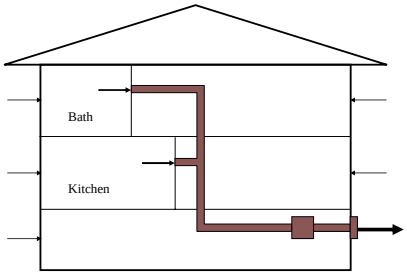
Central Exhaust Fan



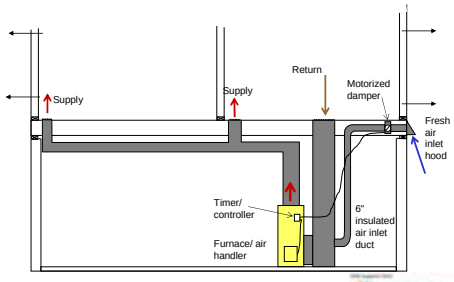
Quiet Bath Exhaust Fans

24-hour Timer Control

Remote Exhaust Fan



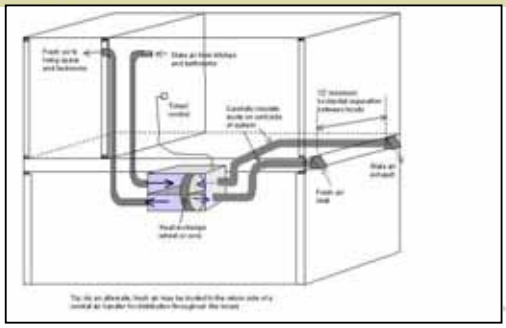
Return Duct Fresh Air



Return Duct Fresh Air

- Needs proper control (www.fancycler.com)
  - Initiate vent-only fan cycles
- Needs motorized damper to limit vent cycles in peak conditions
- HVAC equipment must be correctly sized!
  - If oversized, large fan energy penalty

Heat or Energy Recovery System

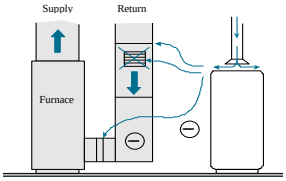


ENERGY STAR® Requirements: Combustion Equipment

- Sealed Combustion 90% furnaces are required
- Naturally drafted combustion equipment must operate properly (Water Heaters)
- Induced draft (power vented) or sealed combustion water heaters are recommended
- Combustion Appliance Zone testing is required

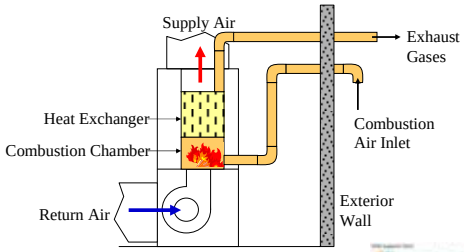
Combustion Safety

- Natural Draft appliances are “open” and can allow exhaust gases to enter home
- Backdrafting can occur when a natural draft appliance competes for air with other appliances, fans, or leaky return ducts

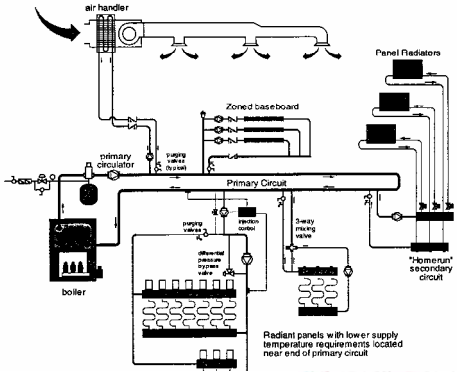


Sealed Combustion

Sealed combustion, separate from house air



Minimizing Combustion



Hydro-air System

Condensing Water Heater

- Provides heat and hot water
- Hydronic heat or hydro-air
- Sealed combustion
- Stainless tank

ENERGY STAR® Requirements Heating and Cooling

- HVAC contractor must supply sizing calculations for Heat Pump systems
- Ducts in unconditioned spaces must be insulated(*R*-8)and sealed with *mastic*
- Ducts must be performance test for air leakage
- 90% efficient gas furnaces
- 13 SEER AC
- 8.5 HSPF after July 1, 2006 (8.0 for homes signed up before 6/1/06)

System Sizing and Design

- Avoid "rule of thumb" sizing methods
- Calculate room-by-room heat loss and heat gain using industry standard such as **Manual J**
- Apportion distribution system according to heating and cooling loads of each room

Quotes:

- "If an air conditioner runs for only five minutes instead of 10 minutes, you lose 1 point on the EER scale."
  - John Proctor

System Sizing and Design

- Provide HVAC contractor with plans and specs that include:
  - R-value of exterior building components
  - Estimate of air leakage rate
  - Window and door schedule
  - Floor plans, elevations, cross sections
  - House orientation
  - Framing plans (for central air systems)

HVAC in the Attic

- Disadvantages
  - Equipment & ducts in "outdoor" environment
  - Increase total heat loss and gain
  - Duct leaks cause air exchange between house and attic
  - Heating attic can lead to ice dams
  - Difficult to access and service equipment

Bring the Ducts Inside

- Eliminate need to insulate / seal ducts
- Reduce length of duct runs
- 2x6 interior wall(s) to allow duct risers
  - Stack framing, floor registers
- Avoid attic ducts
  - Pay attention to sealing
  - Keep low to insulate over
- Avoid using stud/joist cavity as duct
  - ACCA says to avoid this technique

Hydronic Issues

- Zone Control – differing loads, overheating
- Outdoor reset – proper settings, sensor location
- Overheating – rooftop boilers, cold start, proper sizing
- Condensing controls
- 2-pipe fan coils without dampers – no control

HOUSE AS A SYSTEM
Home Building Solutions Workshop

Duct Sealing

Ducts Inside

Why?
- **Temperature**
- **Condensation**
- **Leakage**

Ducts Inside

Why?
- **Temperature**
- **Condensation**
- **Leakage**

How?
- **Design**
- **Dropped ceilings**
- **Soffits**
- **Interior walls**
- **Unvented crawls**
- **Conditioned attics**

Why Seal Duct Leaks?

- Reduce heating system efficiency
- Increase air leakage
  - 30-300% while blower is running
- Reduce comfort
  - drafts
  - unbalanced air delivery
- Promote combustion backdrafting

ENERGY STAR Requirements

- All duct connections outside thermal envelope must be sealed with mastic
- Duct tape or foil tape is not permitted
- Duct leakage must be measured by an approved Performance Tester

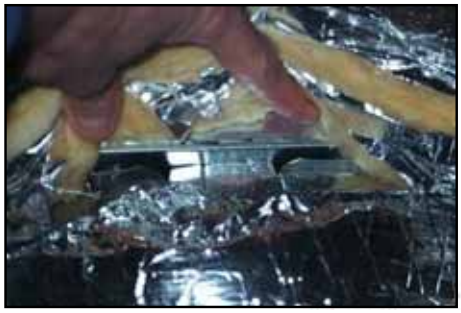
ENERGY STAR Requirements

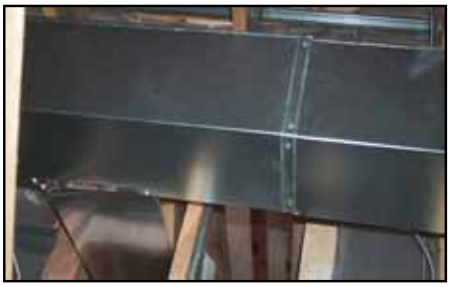
Standard:

- Maximum total leakage of 6% of floor area (sq.ft.) at 50 Pascals
- Example: 2200 sq.ft. house
  2200 x 0.06 = 132 CFM@50

Worst duct leakage areas

- Swivel elbows
- Branch takeoffs from trunk ducts
- Other finger jointed connections
- Folded corners of boots and other fittings
- Filter racks, other plenum connections
- Sealing only the connections between duct sections will result in a leaky system!
- Missing pieces!





One-year-old falls into air duct

GROTON, Mass. (AP) — A baby boy slipped into a heating duct at his home and disappeared, but was rescued unharmed, police said.

Police received an emergency call at about 4:30 p.m. Monday from the 1-year-old boy's mother, who said the child had slipped feet first into a duct in the floor, police dispatcher Lee Jeddrey said.

"Somehow the child got in the air duct and got stuck," Jeddrey said. "When the mother first called, she could see his head. But then she couldn't see his head anymore."

The mother had already turned off the furnace by the time she phoned police.

The child was taken to a hospital in Ayer, where he was examined and later released.

Jeddrey said rescue workers freed the child in about 10 minutes.

Duct Sealing Essentials

- Use Mastic
- Use Mastic
- Use mastic and mesh tape
  - For larger gaps
- Seal the inner duct material, not the vinyl wrap
- No tapes (including butyl tape or “mastic tape”)

THE BOSTON GLOBE • MONDAY, AUGUST 31, 1998

Duct tape has this one flaw

By David L. Chandler
GLOBE STAFF

What's duct tape good for? Just about everything, it seems, from making stopgap repairs on briefcases and **Zero Gravity** upholstery or household tools and appliances to patching holes in the screen porch. Whatever it is, if it's broken, duct tape can probably fix it.

Okay, what's duct tape no good for? Taping ducts.

And that's straight from a team of scientists working at a major government research lab.

After three months of rigorous comparison testing at the Lawrence Berkeley National Laboratory, a US Department of Energy facility that spends most of its time trying to develop things like futuristic fusion-powered generat-

ZERO GRAVITY, Page C4

Continued from Page C1

ing systems, the team concluded that the ubiquitous, ultra-sticky gray stuff we call duct tape fared worse than everything else they tried when it came to sealing ductwork in heating and air conditioning systems.

"We tried as many different kinds of duct sealants as we could get our hands on," said Max Sherman, head of the Energy Performance of Buildings group at the prestigious California lab. "Of all the things we tested, only duct tape failed. It failed reliably, and often quite catastrophically."

But as strong and sticky as duct tape is when you apply it, apparently it's going to need a new name. Put it on a duct, and it's going to crack, split, and fall off before you can say "jumping heating bills!"

And that's the issue, say the earnest government scientists. Duct tape may sound like a frivolous subject for research, but the fact is that an enormous amount of energy is wasted if hot air spews out of joints in the ductwork and ends up heating the basement, crawlspace or the insides of walls, instead of your home.

"Duct tape failed. It failed reliably, and often quite catastrophically."
MAX SHERMAN

In the Berkeley tests (which tortured the tape with rapid heating and cooling cycles to produce accelerated aging) most of the duct tape failed within days. Most of the joints ended up spewing out at least half as much air as they did before the tape was applied.

Everything else the researchers tried worked better: Clear tape, foil-backed tape, mastic, and a newly-developed aerosol sealant all held up under the tough testing. Only the duct tape failed.

The aerosol sealant, developed at the Berkeley lab, worked best of all – and it may be the easiest to use. Instead of laboriously taping or painting the material over every joint, you simply squirt the spray through the duct system; it settles into the leaky places and seals them shut. After two years of testing, those seals were still holding like new.

Details of the energy lab's findings were published this summer in Home Energy magazine. But the work leaves one lingering question. Among the various kinds of duct tape the team tested, there was one – which worked no better than the others – that was described as "no-clear grade."

Just what, exactly, is that being used for?

On second thought, maybe we don't want to know.

▶ *Zero Gravity is an occasional look at the not-so-serious side of science.*

THE BOSTON GLOBE • MONDAY, AUGUST 31, 1998

Duct tape has this one flaw

Taping Ducts

Energy Efficient Lighting

Requirement

•50% of all sockets

•ENERGY STAR labeled

Energy Efficient Lighting

Requirement

•T-8 or T-5

•Electronic ballasts

Energy Efficient Lighting

Sequence for Success

Linear
- •Garage
- •Utility
- •Undercabinet

CFL
- •Ceiling “dish”
- •Wall sconce
- •Pendants
- •Outdoor
- •Recessed

HOUSE AS A SYSTEM
Home Building Solutions Workshop